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The Foundation of Future Spectrum

By Thomas Kidd - October-December 2005

The radio frequency electromagnetic spectrum is more important to the Department of the Navy (DON) today than it has ever been in the more than 100-year history of radio. As the diversity of spectrum applications grows, the complexity of obtaining spectrum support grows accordingly. Along with engineering, coordinating and managing the tens of thousands of frequencies used in today's complex radio systems, Navy spectrum managers also use and maintain a wide array of databases. Without them it would be impossible to reliably operate radar, telemetry networks, microwave data links, mobile radios or anything dependent on a frequency in the electromagnetic spectrum.

Automated net-centric spectrum management tools of the future will rely on these databases, as cognitive radios of the future autonomously adapt to meet the needs of a dynamic battlefield. Highly accurate and up-to-date databases are the foundation of future spectrum management.

Two Fundamental Types of Databases

There are many sources for information used in spectrum management including national and international radio regulations, maps and geodetic information, propagation studies, sunspot numbers and more. At the core of spectrum management are two fundamental types of databases. The first contains documents detailing what equipment characteristics are certified and authorized for use within the United States, its possessions and host nations in which the DON operates.

The second database contains detailed licensing information of how individual radio frequencies are assigned for use within the United States, its possessions and host nations around the world. When these two databases are combined, they form the picture of not only how the DON uses the electromagnetic spectrum today, but also what portions of the electromagnetic spectrum are available to meet requirements in the future.

Equipment certification defines how a spectrum-dependent device may operate within the electromagnetic environment. Detailed data are registered, defining all the characteristics of the transmitter, antenna and receiver. Usually a transmitter is capable of more power, features or greater bandwidth than the spectrum can support everywhere the DON operates. This is why the database also includes information about how the system is authorized to operate.

Limitations may vary from location to location and country to country. Certification of spectrum-dependent devices can begin as early as the conceptual stage of development. As a device is developed, the spectrum community is able to provide the guidance necessary to successfully operate the system in the congested, highly regulated radio frequency spectrum environment. Restrictions are also defined in the certification database to assure that operations abide by local, national and international radio regulations.

Frequency Assignment

Frequency assignment is the licensing of an individual radio frequency in a particular geographic area. The assignment database lists detailed parameters that define the electromagnetic radiation from an antenna. These parameters include the maximum power authorized from the transmitter, the maximum antenna height, the amount of spectrum occupied by the transmitted signal and the type of modulation used.

In addition to the technical characteristics of the signal, the assignment databases also contain administrative information about who is authorized to use the frequency, under what conditions it may be used and what equipment is authorized to transmit. When combined, the equipment and frequency databases contain nearly all the information needed to determine the characteristics of the electromagnetic spectrum-dependent devices that the DON operates, at any time and in any place.

Years ago, radio frequency spectrum management was done with mechanical slide rules, formulas, best guesses, rules of thumb and hours or sometimes days of labor to predict characteristics of the electromagnetic environment. Cognitive radios that continually reprogram themselves to maximize

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the local spectrum must do all this and much more in less than the blink of an eye. Success depends not only on the advanced technology of future radio systems, but also on today's spectrum manager updating and maintaining an accurate database.

Net-centric spectrum management uses the information in the equipment and frequency databases to dynamically model the spectral environment while software-defined cognitive radios will determine the best frequencies and transmission parameters to complete communication. With accurate information, the next generation of spectrum management automation tools will model and predict the electromagnetic environment. The accuracy of these predictions depends entirely on the accuracy of the databases. Therefore database accuracy is essential.

Many of today's spectrum records are decades old and not detailed enough to support the electromagnetic demands of future radio systems. The engineering tools may not have been available, or the level of detail was not required for equipment certification and frequency assignment when the system first entered the inventory. Some transmitters have been in operation for nearly as long as there has been spectrum management.

In 1952, the U.S. Navy built a very low frequency transmitting station located at Jim Creek, in Oso, Wash., and it is still in operation. On the other hand, many modern systems are so complex they do not conform to the current certification and assignment processes. Nevertheless, the DON spectrum management community is actively engaged in aggressively updating and validating all spectrum-related databases.

Frequency Reviews

Radio frequency assignments are generally reviewed at least once every five years. During the review process a spectrum manager evaluates all electromagnetic parameters of the system and compares it to the data in the record to verify it is accurate. The five-year review process is also an opportunity to add data omitted from the original application or update data which may have changed. Even small data errors such as incorrect latitude or longitude for transmitters or receivers, erroneous antenna heights or terrain elevation can all result in frequency assignments that cause interference with another system. The frequency assignment is the license that authorizes the DON to transmit, and it must be accurate at all times.

There are no periodic reviews of equipment certification. However, whenever there are modifications or upgrades, they are added to the certification. Also, when the associated frequency assignment is reviewed, spectrum managers review the equipment certification. New capabilities or modifications to the equipment are recorded along with any administrative changes. Sometimes, new restrictions or rules regulating operation are also added. Occasionally equipment replacement or upgrades require the spectrum manager to submit new documentation requesting certification of new equipment recently added to the inventory.

The DON is one of the federal government's largest users of the electromagnetic spectrum. The Department's interest in the electromagnetic spectrum is straightforward — ensuring spectrum access for the U.S. Navy and Marine Corps. Access to frequencies for required training, day-to-day support and operations is a paramount concern and a priority endeavor of the DON. Given the fact that spectrum reallocations, policy determinations and new allocations all have serious consequences for the DON, it is in the Department's best interest to be as good a steward as possible in our use and management of spectrum.

Thanks to a dedicated group of professional spectrum managers working in the fleet, ashore and throughout the chain of command, the Department of the Navy will be ready with a strong foundation to build the future of spectrum management.

What has the DON CIO Spectrum Team Done Lately?

• Participating in National Telecommunications and Information Administration (NTIA) working groups and coordinating with DoD to formulate a consolidated DoD position for development of the Presidential Strategic Plan for Electromagnetic Spectrum Management.

• Developing a Land Mobile Radio policy in conjunction with ASN (RDA), HQMC C4 and OPNAV N46 for effective emergency communications. It will establish standards for encryption and interoperability within the DON.

• Worked with the DoD and the Federal Communications Commission to resolve a consumer garage door radio frequency interference issue by locating new frequency assignments for garage door openers away from the frequency used by first responders near Camp Pendleton, Marine Corps Base Quantico and Navy Region Northwest.

• Sponsored and led the introduction of DON XML Naming and Design Rules (NDR) into the Afloat Electromagnetic Spectrum Program (AESOP) software upgrade. The NDR-compliant version of AESOP proved so successful during Trident Warrior 2004 exercises that the Chief of Naval Operations recently mandated its use in all communications and radar planning.

• Led a Department of State delegation at the Inter-American Telecommunication Commission meeting in Argentina — a coalition of 35 countries from the Americas that collaborate on

spectrum policy and use issues. As a result, the DON will be included in U.N. treaty negotiations,

which will ensure that the Navy's equities are protected and that warships can operate with impunity.

• As an international chair of the International Telecommunication Union (ITU), identified the need for and initiated a global study to recommend technical standards to protect maritime communication systems.

• As the DoD representative, worked on developing the U.S. position on the technical, operational and regulatory provisions regarding the use of spectrum by space services to reduce the risk of encroachment and reallocation into DoD-designated frequency bands.

• Rallied Australia, Russia and the Arab States at the U.N. proceedings in Geneva to oppose a European proposal to reserve certain frequency spectrum bands, thereby preserving the maritime mobile allocation for the DON's continued use.

• Coordinated more than 570 radio frequency assignments for the DoD in support of Hurricane Katrina relief operations. This included coordination between the DON CIO, OPNAV, HQMC and the Navy Marine Corps Spectrum Center.

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TAGS: Spectrum, Telecommunications, Wireless